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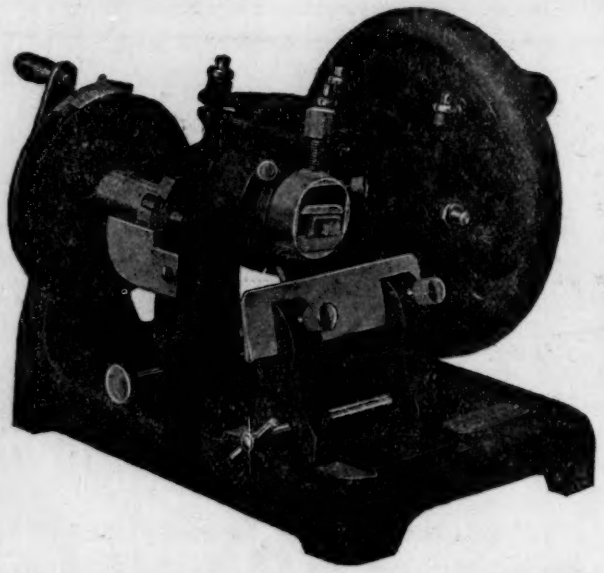

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GEOLOGY IN EDUCATION[1]

WHAT would be the result if those who are interested in education could come *de novo* to the question of the content of an ideal curriculum of study? It probably is safe to say that one of the results would be a shock to those whose opinions on this matter have been shaped by the prejudices which accompany our inheritance. That evolution is a slow process is illustrated nowhere better than in educational circles.

Let it be assumed that the consideration of what is most valuable in education could be approached by a jury which has an intelligent grasp of all subjects, as now understood, and of these subjects in their proper relations. Let it be assumed further that the jury is unprejudiced by tradition or by pronounced personal bents in favor of or against individual subjects. What conclusions would they reach? To this question there is of course no categorical answer. Wisdom would decree that there is no one model curriculum—that there should be various types of curricula, each susceptible of adaptation to individual needs.

The classes of subjects whose claims would need to be considered in such a study as that here suggested fall into several general classes. It goes without saying that their values would be differently gauged by different men, and that their values are different for different men.

Without presuming to make an exhaustive classification, it is clear that one great

[1] Address of the vice-president and chairman of Section E—Geology and Geography—American Association for the Advancement of Science, Pittsburgh, December, 1917.

group of subjects deals with men, what they have thought and what they have done, how they have moved on from one mode of thinking and doing, to other modes of thinking and doing. In the evolution of education, it came about that great importance was attached to the languages in which people recorded what they thought and did; but if we could come to this question anew, with all modern facilities for getting the things which are recorded in one language into available form in another, it is not clear that languages which are no longer in use would be regarded as vitally important for the average student. If it is important to know what was thought and done in the past, as it doubtless is, there must be scholars who command the languages in which ancient thought and ancient history are recorded. They should be our interpreters, who put into modern language the valuable part of that which is recorded in languages which are no longer spoken.

I suppose no more conspicuous example of intellectual waste can be pointed to in all the history of our unintelligent educational development than the waste of time on languages which no longer live. The stock argument that the study of these languages is helpful in the use of our own, is an argument for waste. If half the time were devoted to English, which is put upon Latin for the sake of helping English, the average student probably would advance much farther in the use of his own tongue.

What the people of long ago thought and did is of importance chiefly in its bearing on modern life. This bearing should not be belittled, and is a sufficient warrant for the study of ancient history, and of the philosophies and literatures from which our modern philosophies and literatures are descended. Yet it is easy to exaggerate the importance of even these things. Some one has told us that "history is always interesting, but rarely instructive." Such epigrams, and this one is as true as most, warn us of the futility of depending too much on the past for guidance. While history helps us in some measure to understand what is happening in the present world-crisis, yet all history, ancient and modern, plays a trivial part as compared with geography, chemistry and physics, in explanation of the course of the present war. History will in the end be invaluable in the interpretation of the war, but its importance in the crisis is slight. The dictum that history repeats itself can hardly be taken literally, or even very seriously. If it does, it repeats with variations so extraordinary that they are more prominent than the theme which they accompany. Nevertheless, that which people have thought and done is likely to remain an important element in education, and it is perhaps the sociological and economic aspects of history which are of greatest moment.

In human affairs, the past is important chiefly as a setting for the present. It is the present in which we live and move and have our being, and it is the future for which we are planning. In so far as study of the past helps us in the present, it should be cultivated. Is there adequate basis for going farther, in the average case? I believe that the most serious criticism of the old curricula, some of which still persist, is the undue proportion of time given to the languages and events of times so distant that they have little bearing on the problems of the present.

There is another class of subjects which deals with the present, with facts and conditions of to-day, and with what people are now doing and thinking. Current thought, current political, social, and in-

dustrial life, current processes in the utilization of resources, and progress in the development of principles which are to guide activities and affairs in the immediate future, these are the themes of this group of subjects. If we could free ourselves from the bias of tradition, can it be doubted that in a perfected outline of study these subjects would have a far larger place than they have had in the past, or than they have now in many institutions? Modern history, modern sociology, modern industrial life, modern economics, modern science in its application to human welfare, conservation—these are things which fit men and women for life in the present, and prepare the way for life in the future. In the successful prosecution of these studies, the languages in which the current record of their development is writ, are, of course, important.

Two years ago, I heard a Phi Beta Kappa man, just graduating from a large university, say that he felt absolutely out of touch with current affairs, that he knew far less about what people are thinking and doing, than he did when he entered college. That a normal man could make such a statement on completing a college course, seems to me a reproach to modern college education. Present-day thought, and present-day activities in connection with vital problems should, it seems to me, enter in a large way, into the curriculum of every normal student. And, for my part, I should be particular only that there be enough of the past to give a proper setting for the present, making provision always for the specialization of the exceptional student on any phase of any subject, at any stage of its evolution.

There is a third class of subjects which deals with facts and principles which have no necessary relation to historic time. The time element is involved, in many cases, in the development of facts and the evolution of principles, and in this connection it may be of vital importance. In many cases the history is interesting rather than instructive, but in others the bearing of principles and the significance of their application are revealed by their history, a history based on natural laws rather than on the caprices of men.

To this class belong most of the subjects popularly designated "science." The underlying principles are immutable, though their interpretation has changed from time to time, chiefly in the direction of completer understanding; and this change of interpretation is sure to go on, perhaps indefinitely. Once principles are established, further progress is by way of their development and enlarged application.

Most of these subjects involve an element of history which can not be ignored. There is the accumulated and accumulating body of fact on which interpretation is based. To the average student, the details of this history are not very vital, but to the specialist in any science they are vital, for in many cases facts are temporarily misinterpreted, partially interpreted, or even uninterpreted, for long periods of time. They must be stored until the time comes when they can be fitted into their proper places and their true significance grasped.

Geology belongs to this class of subjects, and among subjects of this class perhaps no one is better qualified to really educate the student.

In the first place, this is the earth we live on. It is the home of man, the only home of the only men that ever were or ever will be, so far as we now know. The past, the present, and the future of the human race, to the best of present knowledge, are bound up with it. They have been, are, and will be dependent on con-

ditions which exist here. They are intimately connected with the resources which science has discovered and learned to use, for it is reasonably certain that our progress in this direction is not ended, and quite possible that it is only well begun. Progress in the utilization of earth resources involves the results of sciences other than geology—especially chemistry and physics.

It is of course known, but not widely realized, that a large proportion of the people of the earth gets its living from the utilization of the materials of geology. The workers of the soil are not only making use of geologic materials daily, but are dependent on them. The efficiency of soil-workers would, in the long run, be far greater, if they understood how soils come into existence and how they are lost, how they are exhausted and how their exhaustion may be prevented. To supply this knowledge to soil-workers would be to increase the products of their labor, to better their condition, and to feed the rest of the world more cheaply. Have we any right to withhold such knowledge from the youth who are to deal with the soil? It is true that they learn much empirically. It is true that agricultural colleges and the Federal Department of Agriculture are supplying much useful information to large numbers of men, young and old; it is true that almost any man can gain needed information of a practical sort on these subjects, if he is well enough informed to know what he needs, and how to get it.

But in spite of state and federal efforts in this direction, large numbers of soil workers are still as ignorant as may be of the principles involved in the making and preservation of the material with which they work. Many of them are doing as their fathers did, because their fathers did it, just as we who ought to know better are still requiring or encouraging young men and women to study the things that their ancestors studied, because their ancestors studied them. No one can say how much more efficient our farmers would be, if they understood the principles of soil making, soil waste and soil exhaustion; but it is fair to infer that if they understood these things, the result would be so convincing that it would be better to neglect almost anything else rather than these things, in the education of those who are to gain not only their living, but the living of the larger part of mankind, from the soil.

Then there are the workers in mines of all sorts, who take from the earth beneath the soil the many things necessary for the on-going of modern life, and for the progress of commercial and industrial life in the future. This has been called the age of steel. It were better called the age of metals, for much besides steel is involved. The discovery of metals and fuels and progress in their utilization is tied up closely with the progress of geologic knowledge, and without the progress of geologic science the advances which have been made would not have been possible. It is of course true that in the final production of metals from ores chemistry has played an important part, but it is geology which has led the way in the discovery and exploitation of the raw material, because it has discovered the principles, or some of them, involved in their origin. It is true that geologic knowledge on the part of one man may direct the development of resources where many do the actual work; but it would be interesting to know how the mining industry as a whole would be affected, if all mine-workers understood the facts and principles involved in the origin of the materials which they extract from

the earth. How far would such knowledge go toward solving the many problems which face every mining camp, and every mining mill and smelter? How far would it go in removing labor troubles, in averting accidents, in bringing about a just distribution of profits in mining camps? To such questions specific answers are not forthcoming, but they are worthy of the most serious study, and their study may lead to a better understanding between capital and labor, and a better adjustment and an adjustment by better means, of their respective claims. Incidentally, if some of these things were better understood by those professional reformers who always take the the side of the dissatisfied, better results might be hoped for. The ignorance and therefore the incompetence of the sincerely well-disposed is one of the great obstacles to real progress.

The oil industry and all that goes with it furnishes another illustration of the importance of geologic knowledge, an importance which daily is assuming larger proportions. The rise of the cement industry is another of the great achievements of modern times in which geology has been an effective partner.

All these things concern themselves with industrial and commercial life, and what has been said may seem to place undue emphasis on material things; but I hold that these are first considerations. Men must have enough to be decent and to live decently, before their attention can be successfully directed to those things which we are pleased to call "the higher things of life." Ethics, esthetics and scientific research can hardly hope to find many effective exponents among the underfed and underclothed. In spite of what the rare individual may do, or of what the average individual may do under temporary exceptional conditions, few men, in the long run, will do much that is noble, much that contributes to progress, in the absence of something more than the mere necessities of life.

But there is quite another aspect to geology, which does not concern itself immediately with income or with industry. The study of geology involves the contemplation of things which are enlarging and ennobling, in a spiritual sense. No education which leaves out training of the imagination is properly enlarging or ennobling; and where, outside of science, is there such opportunity for developing and training the imagination, and where in science, a better field than geology? The time-conceptions involved, the force-conceptions involved, the results involved in the operation of time and force, are among the greatest with which the student has to deal. They strengthen the mind by exercise of a sort which few other subjects afford. In space conceptions, astronomy surpasses it; in their appropriate spheres, physics and chemistry are equally effective for the educational ends here emphasized; but on the whole, no science surpasses it.

No subject affords a better field for the development of that sort of attitude of mind which seems especially to fit men for life. While there are phases of the subject which deal with facts and principles which lead to inevitable conclusions as certainly as mathematical reasoning does, there are other phases in which reasoning of another sort is called for. In most of the affairs of life, decisions are based on a preponderance of evidence. In few momentous decisions is the evidence so clear that there is but one side to the question. Rarely is the evidence 100:0; it is 75:25, or 60:40, or 51:49. And training in weighing evidence which is not overwhelmingly one-sided is one of the most important functions of education, for most of the

important decisions of life are reached by the balancing of conflicting evidence. Thorough training in geology must lead to the balancing of seemingly conflicting evidence, for there are multitudes of questions to which the student of even the elements of the subject is introduced, concerning which evidence must be weighed, and a tentative decision reached, with a full recognition of its tentative character. The recognition of this character of a conclusion opens the way to a revision of judgment when additional facts warrant, and this attitude of mind is the attitude to which good education should lead in connection with all questions where evidence is inconclusive, and this means in connection with many of the affairs of life.

No claim is set up that no other subject does the same thing. As a matter of fact, some do and some do not; but the claim is set up that the type of subject which works on strictly mathematical lines can not, by itself, afford the best preparations for the solution of the average problems of the average man. Neither can other types of subjects which do not involve the balancing of evidence, and the development of the power to separate what is weighty and relevant, from that which is light and irrelevant.

We progress from the uncertain to the certain. There are numerous problems in geology which were unsettled a generation ago, which have been solved now. There are many open questions now, which await solution. No subject better than geology gives training in the methods by which uncertainties are cleared up, by which stimulating but unverified hypotheses are tested, and advanced or rejected, as the case may be.

One of the great lessons which the world needs most to learn is that progress comes from cumulative achievement. If every individual could be made to realize that even his tiny contribution to the sum of useful work is really moving the world along, it would add grandeur to life and dignity to all human endeavor. This is a frame of mind that should be developed in every young person, and cultivated till it becomes a habit. Where can this be done better than in connection with such a subject as geology, where the stupendous results of processes which, day by day, seem insignificant, are constantly under consideration. Nowhere else in the whole range of subjects in our ken is the majesty of the cumulative results of seemingly slight processes more sharply emphasized and more constantly reiterated.

Processes are at work on the land which, by themselves, would in time destroy it utterly. They have been in operation so long that they would have accomplished this result eons ago, if nature had not provided counter-activities which defeat this end. Nowhere is the inter-play of constructive and destructive forces, using these terms in their bearing on man's life and welfare, more pointedly studied.

Dr. J. M. Clarke pointed out years ago that the study of paleontology afforded the basis for much of the philosophy of modern life. Professor Chamberlain has taken the general position that the study of ancient life is the proper starting point for the study of sociology. Unquestionably these men are right, at least in the claim that some of the principles which have been worked out laboriously in connection with modern human life, are well illustrated by the history of organisms long since extinct. It is perhaps too much to expect the sociologist to become a paleontologist first. Probably there is no more reason why he should, than why a man who wishes to use the English language well, should first become a Latin scholar. But it is

quite possible for the sociologist to lay hold of the principles which paleontology illustrates, if paleontologists will but put them into form available for application outside the field of fossils, just as it is possible for the student of the English language to lay hold of that which is vital for his purposes in the Latin language, by short-cut methods. Analogies between the courses of events in the history of Cambrian life, and the course of human events in modern times are interesting if not instructive, and they are doubtless more numerous and more pointed than the superficial student suspects.

One of the chief functions of education is to put man into sympathetic and appreciative touch with his surroundings. His physical surroundings are an important part of his environment, always and every where, and he who does not understand, is cut off from one of the great resources of life. It is of course true that one may enjoy a landscape, even if he does not understand geology; but he will enjoy it more if he does. A man may enjoy pictures and music without understanding much about them. but he will enjoy them more if he understands. And just as some education in music and art is to be desired because it increases a man's capacity for enjoyment of the things which he sees or hears occasionally, so education with reference to the landscape, which the average man sees much more than he sees works of art, and much oftener than he hears music, is a desideratum. To go about the earth blindly, unintelligent as to the meaning of its surface configuration, is to cut off one of the great pleasures of life, and especially one of the great pleasures of travel.

Since all men are in touch with at least a limited part of the land surface, and most of them in touch with enough of it to find lasting enjoyment in it if they are taught to see what it means, is it not reasonable to conclude that the subject which teaches them to see understandingly, is one which it must be profitable to pursue? How can we justify ourselves, if we withhold this resource from this and coming generations?

Prompted by the attitude of mind which mountains inspire, I have repeatedly watched their effect on groups of students who, for the first time, live in them long enough to have their influence felt; and I have seen, or thought I saw, how littlenesses and meannesses drop away, and how the nobler qualities come to the fore. John Muir has made much of this idea in one connection and another, and I think he is entirely right. To many men. mountains are as inspiring, as uplifting, as soul-stirring, as great essays or great poems are to others. Is it not just as great a mistake to leave the one out of consideration as the other? To the average young *man* at least, I suspect that mountains are quite as much of an intellectual and moral tonic as the best that he finds on the printed page.

What has been said of the mountains might be said, with modifications, of other parts of the earth. If there are those who think the landscape of an unrelieved tract like that about Chicago unlovely, I think this feeling would be changed completely if the grand march of events which has made that surface what it is, were understood. While it can never have the charm to the eye that some other sort of surface has, it has its own elements of attractiveness, its own beauty, to the eye which really sees. When men belittle the attractions of the level prairie, they advertise their ignorance. One may not chose to see the flat land all the time, any more than one would choose to read poetry all the time. With equal education in the two, I am confident that the normal man could live contentedly

with the plains longer than with poetry—even of the best.

The sea has a charm for almost every soul, but he who gets only what the eye records of color and movement, fails of the larger meaning, which, to beauty, adds grandeur. What does the salt of the sea mean? What is the period of time of its accumulation? What volumes of rock—many times all that is now above its surface—have been destroyed in its production? What range and volume of life, of which the voyager has but a glimpse, does it harbor now? What of the life of which it has been the home in the time which has passed since life was, and what of the great evolutions that have taken place within it? And what is yet to come? The great panorama of events, of processes, of changes, all of which are involved in the history of the sea, add a meaning larger than the eye, unaided, sees. To see the ocean merely as it is is like seeing the social fabric of to-day, without reference to what has been in the past, or what is to be in the future.

Our period of schooling is all too short to give us an intelligent look into all the fields with which it would be profitable to have acquaintance; but is this field on which we live and move and have our being, one we can afford to neglect?

From a wholly different point of view, geology is a valuable study. There is no subject in the curriculum which, rightly developed, can be made to lead more surely to correct methods and processes of reasoning. I remember that a former president of the Geological Society of America said, in his annual address, that the first courses in geology must be pouring-in processes, and that only later can anything be drawn out. In a sense this is of course true; but in another sense this doctrine is at the root of all that is worst in education. Geology, better than most subjects, can be taught from the beginning by the problem method. Given certain specific data—and the data may be in strict conformity to the facts of geology—the student can work out for himself the results which must follow. By this method, skillfully carried out, any man with ordinary intelligence for the comprehension of cause and effect can be let into the heart of the science with a minimum of information poured in, and that minimum bit by bit for use in the solution of problems. This method of instruction educates, but does not stuff him. The lecture method of instruction in the elements of geology, when well done, is hardly more than a stuffing process; when badly done, it is much less. In any case, it leaves the student relatively helpless in dealing independently with the reasons which give facts this meaning.

No subject within my ken lends itself better to this method of problem study than geology. In its simpler aspects, it deals with facts with which the student has some familiarity, and he can be led to reason from the known to that of which he has not thought, so that the work is, for him, original research from the outset. This is ideal education, and for this sort of education, geology is almost an ideal subject. We have heard much of discipline in education. This is the sort of discipline which counts.

There is much in the history of the science which is illustrative of the history of intellectual progress. It is not so long ago that one man's guess was about as good as another's, concerning anything that had to do with earth phenomena, and it was long years after facts began to be observed, before the convincing worth of facts was generally recognized. The history of the attitude of men toward fossils is typical of their attitude toward the science as a

whole, and is interesting, if not instructive. Though some part of the meaning of fossils was sensed by Xenophanes in the sixth century B.C., his views were soon lost, and did not reappear until the fifteenth century, when Leonardo da Vinci reaffirmed their genuineness, combating both the idea that they were accidents in the rocks, and the idea that they were introduced for purposes of deception. It is a curious fact that it was the defenders of the faith, who by their professions might appropriately have been the most valiant defenders of the integrity of all that the Creator had made, who, to prop up certain beliefs which they feared were in danger, ascribed to the Creator ignoble motives in introducing the fossils into the rocks.

Once the integrity of fossils was accepted, the conception that they were proofs of the biblical deluge had still to be reckoned with, and it was not until recent times that paleontological knowledge became so ample that *speculation* as to the meaning of fossils gave place to the noble conceptions which now obtain concerning their interpretation. The history of the subject is one of the best illustrations in all the realm of knowledge, of the potency of facts, and of the futility of generalizations without facts, and at the same time one of the best illustrations of the folly of bolstering up a lost cause by specious and ignoble arguments or affirmations.

The enlightening doctrine of organic evolution, which has perhaps done more than almost any other single doctrine to put the progress of the world on a safe track, would not have made the rapid progress it has in the last half century or so, had not the facts of geology given their powerful aid. Nowhere else can the general principles of biological evolution find more convincing support, and nowhere else can the wide application of the doctrine through long successions of ages, find unequivocal illustration. Geology therefore is one of the foundation stones of the doctrine which perhaps has done more than any other to develop the modern spirit of progress and research.

Probably no subject did more than geology to set intellectual attitudes to rights, after the baneful sway of medieval scholasticism. It became necessary in the end to deny facts or to abandon cherished beliefs, and in the long run there could be no doubt of the outcome. There can be no doubt that the temporary denial of facts and their obvious meaning was due to the fear of their consequences on current beliefs and doctrines which rested on feeble foundations. Denial was the last resort of the attitude of mind which found itself cornered, and it ended, as this sort of defense always ends, in making the defender ridiculous.

When Section E was organized under the name Geology and Geography, the conception of geography was somewhat different from that of the present day. I take it that the geography of that time was akin to what is now called physical geography; and to many, physical geography still is geography. This science, especially under the name of physiography, has attained an important place in modern education, more in colleges than in schools of lower rank, chiefly because the subject is in more competent hands in the former. Physiography is the surface expression of geology, the expression of the geology of our own times. As such, it is the phase of geology which most directly appeals to many men, the phase which puts him most readily into possession of the information which gives a meaning to the landscape. It was altogether fitting that this phase of geology

should be associated with geology in a section of this association.

But a new science of geography is growing up, almost unknown to those who are not concerned directly with its development. It is perhaps not yet very sharply defined, even to those who know it best, and hardly defined at all to others. It is clear that it is to center about the influences of earth features and earth resources on the distribution, character, and activities of life—life of all kinds. To what proportions this subject may develop, and how sharply its limits will be set, is not yet clear; but it is making giant strides where conditions for its development are favorable. It is actuated by the high motives of all science, one of which is the desire for truth for its own sake; but even more it is actuated by the desire to render its truth serviceable to mankind. Its field overlaps, in varying degrees, the fields of geology, physical geography, meteorology, botany, zoology, history, economics, and perhaps other sciences. But it uses the facts and principles of these sciences in explanation of the distribution, character and activities of life. The physical foundation for this new science of geography is geology, using that term as we should, to include all the earth, not merely the lithosphere. Whether this new science will belong properly in the same section of this association as geology, is an open question. Some phases of it do not find their closest relationships here, while others do. The subject as now conceived by those who are its leaders touches the life and welfare of the human race as intimately and as fundamentally as any other science.

There is one other aspect of both geology and geography, which gives them great educational value. Neither science is completed or nearing completion. There are great things ahead in both. As an organized science, geology is older than geography, at least older than geography in its modern sense, and is the more advanced. While geology has made phenomenal advances in the last half century, the problems ahead are so numerous and so interesting that even an elementary course in the subject, properly developed, opens up great vistas for the future. I believe it to be fundamentally important that young people should be led to see visions, and be inspired by the allurements of future development. Nothing is more conducive to a right attitude toward life in general, than the feeling of the possibility of participation in the progress of the future. In this, geology is not peculiar. Only as it is less advanced than some other sciences has it the advantage over them in this respect. In saying this, I am not losing sight of the fact that but few of those who give attention to geology in their student days will ever go farther; but a comprehension of what is likely to come stimulates an abiding interest, and abiding interest in various lines of work and thought are important elements in a good education.

In modern geography the promise is perhaps even greater, since less has been accomplished. Perhaps no science touches human life and interests more closely, or in more ways. There is, I am confident, no science which, properly developed and utilized educationally, will do more for the development of good citizenship. Its substance perhaps touches the essence of material life, especially on the human side, more intimately than any other science. No other science and no other subject, unless it be sociology and possibly modern history, is likely to do so much to promote sympathetic understanding between the nations of the earth, and this is one of the greatest desiderata not only of this day and generation, but of all days and genera-

tions. For this reason, if for no other, promulgation of the knowledge of modern geography should be furthered wherever possible.

When geography and geology, and subjects which have similar advantages, occupy larger places than they now do in our educational system, I believe that our young men and women will be better equipped than they are now to do their part in transforming a contentious world into a world of righteousness, based on mutual consideration.

Rollin D. Salisbury
University of Chicago

THE REPORT OF THE COMMITTEE TO VISIT THE HARVARD COLLEGE OBSERVATORY

To the Board of Overseers of Harvard College: The committee which you appointed to visit the astronomical observatory begs leave to submit the following report.

Both individually and as a committee we have kept in touch with the work of the observatory, visiting it from time to time and receiving statements from the director as to the condition and progress of the work.

Your committee finds the many researches going on in a most efficient and satisfactory way, and the results are published from time to time in bulletins and in the *Harvard Annals* which now number eighty volumes. The large amount and the high quality of the scientific output keeps the observatory in the position it has occupied for many years as one of the greatest observatories of the world.

In recent reports to you we have given in some detail the results of various special lines of investigation which the observatory has undertaken. In this report we desire to touch on the efforts of Professor Pickering to coordinate the general progress of astronomical science and to bring about a larger cooperation among the different observatories of the world.

One of the objects of the Harvard Observatory as stated in its statutes is "in general to promote the progress of knowledge in astronomical and kindred sciences." This, Professor Pickering has interpreted in the largest and most unselfish sense by laboring to advance the science in any and all ways, whether the particular credit for the work should come to the Harvard Observatory or not. As the object of the study was the same over-arching sky he has always believed that the most successful prosecution of the work would come from the fullest cooperation of those devoting their talents to the common aim.

Modern astronomy has demanded the most extended effort and the greatest concentration of resources extended over many years to produce the large amount of work which lies at the foundation of the astronomy of to-day. These investigations have demanded labors which no individual or institution could produce but have required the combined efforts of great observatories extending over many years.

In addition to this the best results are only obtained by division of labor and a condition where the special man and the particular problem are brought together. The science has now become so diversified that no astronomer has the versatility or the interest to carry on all the required branches of investigation. There is the problem of finance and the man; there is the problem of producing astronomical instruments as well as the man to use them; of taking photographs as well as measuring them; and, finally, the problem of estimating values and drawing reasonable conclusions from all the previous work.

In short, the progress of astronomy, like the advancement of civilization, requires many and diverse talents. It was the early realization of this truth which made Professor Pickering a pioneer in an unselfish policy to secure cooperation among astronomers so that each might be enabled to carry on the particular lines of work for which he is was best fitted.

As early as 1877 he published a pamphlet on "The Endowment of Research" and advocated a closer cooperation looking to the larger interests of the science.

In 1886, a second paper was published asking for an endowment of one hundred thou-

sand dollars, the income of which should be used to aid astronomers in existing observatories to work out their special problems.

In 1890, Miss Catherine Bruce, inspired by this idea, gave six thousand dollars to be distributed in whatever way promised the greatest scientific return. Eighty-six applications were received, showing the great need that was felt by astronomers for just this sort of aid. Fifteen grants were made to men of eight different countries. Among those thus aided we find the well-known names of Adams, Gill, Newcomb, Rowland and Turner. Appropriations were also made to international associations of astronomy and geodesy. It was through this gift that the true explanation of the variations in latitude was discovered, which was in itself a complete justification of the plan.

In 1903, Professor Pickering published a pamphlet showing the valuable results which might be expected by greater cooperation among observatories. He said we find "a great observer but no telescope, a great telescope but no astronomer to use it, and an astronomer whose valuable observations, the results of many long years of hard work, were rendered useless by the lack of a few hundred dollars to publish them." He showed how the appropriation of small sums would add greatly to the scientific output and advocated a sort of astronomical clearing house which would coordinate and support the best good of the science. But the results showed that the time was not ripe for such a forward step, for two leading astronomers declined to serve even on an informal advisory committee. A circular at this time was issued asking astronomers to state the needs of their work. Over one hundred replies were received and gave the best and most complete information ever collected on the subject.

In 1904, the director issued another paper to meet the adverse criticism which the project had aroused. Though the ideas of Professor Pickering were not entirely realized, the plan had the effect of improving the relations between astronomers, and eventually a very large degree of cooperation was realized.

In 1906, an address on "An International Telescope for Southern Latitudes" was given before the American Philosophical Society and the plan received serious consideration by a man of means.

In Science, 41: 82, Professor Pickering issued a questionnaire to twelve leading American astronomers asking them how they would use five thousand dollars if it were given them for research work. As a result of the replies it was found possible, through gifts and grants from existing research funds, to provide for a large part of these needs.

Probably the director of no observatory of the world has done so much for the cooperative ideal in astronomy nor has shown more unselfishness in the practical work of cooperation than Professor Pickering. Instead of trying to build up Harvard Observatory as a separate institution exclusively, he has had deeply at heart the advancement of the science regardless of who should receive the personal credit for the discoveries.

At the present time a large amount of work is carried on in cooperation with other institutions. One of the best illustrations of the value of this method is the determination of positions of the moon by the united efforts of Princeton, Yale and Harvard. Each observatory has carried on the part of the work for which it was best fitted, and which the others practically would have been unable to accomplish. The combined research has resulted in photographic positions of the moon which are, on the whole, the best so far obtained.

The most extensive cooperation in astronomical investigation is the Astrographic Catalogue and International Chart of the Sky. In this great work, now well advanced, the determination of stellar magnitudes was assigned to Harvard, and a large part of the work has now been completed.

By cooperation with the Mount Wilson, Lick and Yerkes Observatories the work has been extended to the faintest stars which now appear on photographic plates.

At present the observatory is determining the standard for the magnitudes of Professor Kapteyn's "Selected Areas." The work is

complete for the northern stars. Professor Kapteyn has thus determined the magnitude of about seventy thousand stars, which are now in print in *Harvard Annals,* Vol. 85.

Professor Pickering has also shown great interest in developing useful work among amateur astronomers. It is through him that the chairman of the visiting committee has been able to do some work on the asteroids. Through lack of expert direction a large part of the efforts of amateurs has proved of little value. An exception to this rule has been the Association of Variable Star Observers, which was formed five years ago and has received much encouragement and help from the director.

During the last year this association of enthusiastic amateurs, consisting of thirty observers, has made eleven thousand two hundred and fifty-two valuable observations of two hundred and ninety variable stars of long period. For this work the observatory has furnished suitable charts and determined the magnitudes of nearly five thousand stars needed for reference, so that all are now measured on the same scale. At a meeting of the Association of Variable Star Observers held at the observatory in November, 1916, nineteen skilled observers made estimates of the magnitude of the same object with the twelve-inch telescope which showed an average difference of less than one-tenth of a magnitude—an experiment altogether unprecedented.

As these observers generally have access to only small telescopes and are therefore unable to measure variables when they are faint, Professor Wilson and Professor Mitchel have shown their spirit of cooperation by kindly agreeing to continue the work with their sixteen-inch and twenty-six-inch telescopes when the stars are too faint to be measured by smaller instruments.

Also it should be mentioned that the observatory is cooperating with the other observatories of the world by furnishing magnitudes and classes of spectra in advance of their regular publication in the *Harvard Annals,* which has been spoken of in previous reports.

These are some of the facts which show the large way in which the observatory of Harvard is interpreting its work, and give some idea of how much Professor Pickering has done to encourage friendly scientific cooperation both here and abroad.

The fruits of much of this work will mature only in the future.

Some of this cooperation the war has temporarily broken but we look to the speedy re-establishment of it when this world calamity be overpast, and it will help to bind up the wounds and soften the animosities which now divide the nations.

The publishing of astronomical discoveries has not entirely ceased even now, and when peace is at last declared the common interest in the heavens will assert itself and bind together those whom the war has separated and estranged. Thus the cooperative study of astronomy will help to give us a new heaven through the interpretation of a nobler science and, through the good will which cooperation aways brings, a new earth, in which dwelleth righteousness.

JOEL H. METCALF, *Chairman,*
GEORGE R. AGASSIZ,
GEORGE I. ALDEN,
INGERSOLL BOWDITCH,
CHARLES R. CROSS,
SAMUEL W. MCCALL,
HERBERT PARKER,
FREDERICK SLOCUM,
ELIHU THOMSON

SCIENTIFIC EVENTS

THE MUSEUM OF THE UNIVERSITY OF PENNSYLVANIA

AT THE close of its free public lecture season the officials of the University Museum call attention to the recent progress of the institution and to some facts in connection with its activities.

Although only in its twenty-third year the University Museum is already recognized everywhere as one of the most important institutions of its kind in the world. Some of its collections are the finest in existence, its expeditions have gone to all parts of the globe,

bringing back rare specimens, while from an educational point of view it has done more than any other museum in revealing the early history of Mesopotamia and throwing light on early culture.

In spite of its youth the real estate, buildings and exhibits are given the very conservative valuation of more than four million dollars, or nearly the value of the total equipment of the entire university as carried on its books when founded.

Its collections of Chinese art are the largest and most representative to be found anywhere in the world, including China.

Its Babylonian collections are the most important in the world and scholars have used them to reveal millenniums of previously unknown history. The museum has published many of its translations, which have made a great impression upon the entire world.

Its Egyptian collections are very large and representative, and when those now held in Egypt until the war ends arrive, the exhibit will be one of the most notable in this country.

Its collections of Eskimo material are the most complete to be found anywhere, and it has a great collection of North American Indian specimens.

Its South American collections, especially those gathered by Dr. Farabee, are not only unrivaled, but the archeological exhibits are the greatest and are almost unique.

Its collections of Tibetan, Indian, Persian and Syrian art are large and valuable.

It has vast stores of valuable art and ethnological material stored away which there is no room now to place on exhibition.

How greatly the museum is appreciated outside this city is shown by the fact that within thirty days $75,000 has been given to the institution by men who have not even visited it, but who know of its value. Of this sum $30,000 has just been given by a New York man, who has watched its career with interest and approval, and has no connection whatever with the university, but desires to increase the museum's educational influences, and, approximately, $35,000 by another benefactor, also a non-resident of the state of Pennsylvania.

The museum is preparing to enlarge its sphere of public usefulness and will shortly issue an announcement of its purposes. It has done much by giving free public lectures Saturday afternoons by the best specialists, has given Wednesday afternoon lectures especially for school children and now desires in the most practical way to further cooperate with all art schools, art clubs, school art leagues and high-school art classes not only in this city but in the entire surrounding country. Already much work has been done by assisting manufacturers who have sought collections in the museum for securing new designs or new ideas, and it proposes to extend this work so far as is possible so as to bring the practical results of the exhibits in touch with the commercial expansion of the city to a greater extent than ever.

RECONSTRUCTION COMMISSIONS OF THE BRITISH GOVERNMENT

The British ministry of reconstruction has just published a complete list of the various commissions and committees that have been set up, both within that ministry and within other ministries and departments of the British government, to deal with questions which will arise at the close of the war.

These commissions and committees, which have been appointed at different times since the war began, now number 87 and fall into 15 groups.

Among the committees on scientific and industrial research are the following:

Fuel Research Board.—To investigate the nature, preparation and utilization of fuel of all kinds, both in the laboratory and, where necessary, on an industrial scale.

Cold Storage Research Board.—Appointed to organize and control research into problems of the preservation of food products by cold storage and otherwise.

Standing Committees on Engineering, Metallurgy, Mining and Glass and Optical Instruments.—To advise the council on researches relating to the lines of activity named and on such matters as may be referred to the committee by the advisory council.

Joint Standing Committee on Illuminating Engineering.—To survey the field for research on il-

lumination and illuminating engineering, and to advise as to the directions in which research can be undertaken with advantage.

Mine-rescue Apparatus Research Committee.—To inquire into the types of breathing apparatus used in coal mines, and by experiment to determine the advantages, limitations and defects of the several types of apparatus, what improvements in them are possible, and whether it is advisable that the types used in mines should be standardized, and to collect evidence bearing on these points.

Abrasives and Polishing Powders Research Committee.—(1) To conduct investigations on abrasives and polishing powders with a view to their preparation and use as one factor in accelerating the output of lenses and prisms for optical instruments, not only for peace requirements but in connection with the war. (2) To investigate the preparation and properties of abrasives and polishing powders.

Food-research Committee.—To direct research on problems in the cooking of vegetables and meat, and in bread making, to be undertaken by two scholars of the committee of council.

Building-materials Research Committee.—To make arrangements for carrying out researches on building construction instituted by the department at the instance of the local government board committee or otherwise, to be responsible under the council for the direction of such researches, and to deal with such other matters as may be referred to the committee from time to time by the council.

Electrical Research Committee.—A committee of direction appointed in connection with certain researches affecting the electrical industry.

Committee for Research on Vitreous Compounds and Cements for Lenses and Prisms.—To conduct researches into the preparation, properties and mode of employment of cements for lenses and prisms; to prepare a reference list of vitreous compounds, their composition, densities, refractive indices and dispersive powers.

Tin and Tungsten Research Board.—The Cornish Chamber of Mines has been invited to nominate a representative of the landlords and a representative of the mine owners to serve on the board. A committee of control appointed in connection with certain researches into tin and tungsten.

Lubricants and Lubrication Inquiry Committee.—To prepare a memorandum on the field for research on lubricants and lubrication, which will contain an analysis of the problems involved, together with a suggested scheme of research, which would be most likely to lead to valuable results.

Provisional Committee on Research and Education for the Cotton Industry.—A committee appointed with a view to the organization of a research association for the cotton industry.

Provisional Committee on Research for the Wool and Worsted Industries.—A committee appointed with a view to the organization of a research association for the wool and worsted industries.

Provisional Committee for the Internal Combustion Engine Industry.—A committee appointed with a view to the organization of a research association for the internal combustion engine industry.

MEETING OF THE GENERAL MEDICAL BOARD OF THE COUNCIL OF NATIONAL DEFENSE

DEDICATION of the Warden McLean Auditorium at Camp Greenleaf, the military medical school at Camp Chickamauga, Ga., on March 11 was made notable not only because of the presence of the Surgeon General of the Army and members of his staff, as well as many distinguished medical men from military and civil life, but also because of the regular meeting there March 10 of the General Medical Board of the Council of National Defense, usually held in Washington. About 1,000 doctors, who as medical reserve officers are taking the three months' course, accepted the invitation to attend extended by Dr. Franklin Martin, member of the advisory commission of the council and chairman of the board.

These members of the General Medical Board attended: Dr. Franklin Martin, chairman; Dr. William F. Snow, secretary; Surgeon General William C. Gorgas, Dr. Victor C. Vaughan, Dr. William H. Welch, Dr. John Young Brown, Dr. John G. Clark, Dr. Thomas S. Cullen, Dr. Edward P. Davis, Dr. William D. Haggard, Dr. Jabez Jackson, Dr. Edward Martin, Dr. Charles H. Mayo, Dr. Stuart McGuire, Dr. John D. McLean, Dr. Hubert A. Royster.

Introduced by Dr. Martin, Surgeon General Gorgas said he knew of no more important work than the activities being developed at Camp Greenleaf; that the necessity of military medical training is obvious; also that on a visit to England five years ago he learned that the great developments in the English

system had been forced by the necessities arising during the Boer War; so, he said, the United States Military Medical Service is being developed by the exigencies now confronting us and would continue after the war. He said he gained from the British service ideas of value for his administration.

Dr. William H. Welch read a statement showing that in February there was an exceedingly satisfactory decline in the admission rates for communicable diseases, as well as for all causes. In the force afloat, the situation as to pneumonia and cerebrospinal fever is very satisfactory. Scarlet fever has been slightly more prevalent than usual but in no sense epidemic; a very satisfactory decrease in measles; mumps continues as heretofore.

For the committee on surgery, Dr. Charles H. Mayo told how data on 21,000 physicians had been gathered and placed on cards convenient for the ready selection of individuals and groups suited for any given task, a duplicate set of which cards has been prepared for the use of the Surgeon General's office in France. Dr. Mayo emphasized the need of reconstructing wounded men, not only for field service but also for labor after the war, inasmuch as the usual tide of immigration has ceased. Citing the many government activities in which medicine enters, he said these relations, he believed, could be coordinated in no way except by having a medical man as a Cabinet officer.

Lieutenant Colonel Victor C. Vaughan, reporting for the committee on legislation, told of the request of the Army medical officers for higher rank and greater authority, and of the Owen-Dyer bill (S. 3748 and H. R. 9563) now pending in Congress. He cited instances which he said indicated need for greater rank, and then read the following letter from President Wilson to Dr. Franklin Martin, indorsing the bill:

I read very carefully your memorandum of February 27 about the rank accorded members of the Medical Corps of the Army, and have taken pleasure in writing letters to the chairman of the Military Committees of the House and Senate, expressing the hope that the bill and resolution may be passed.

LECTURES ON AGRICULTURE

It has been arranged that a group of prominent agricultural speakers shall travel through the northern and western states, after conferences in Washington with Secretary of Agriculture Houston and Food Administrator Hoover to impress on the farmers the necessity of producing large crops during the coming season. A similar campaign already has been conducted in the southern states. The following have consented to take part in the campaign:

Dr. W. O. Thompson, president Ohio State University, speaking in Idaho and Wyoming.

Alva Agee, secretary of the New Jersey board of agriculture, speaking in Ohio.

Dr. A. H. Jordan, director of the New York Agricultural Experiment Station, Geneva, N. Y., speaking in Pennsylvania and Connecticut.

Dr. J. L. Hills, dean of the College of Agriculture, University of Vermont, speaking in New Hampshire.

Dr. C. F. Curtiss, director of the Iowa Agricultural Experiment Station and dean of the Iowa Agricultural College, speaking in Kansas and Nebraska.

Dr. Eugene Davenport, dean of the College of Agriculture, University of Illinois, speaking in Wisconsin.

Dr. W. J. Kerr, president of the Oregon Agricultural College, speaking in Oregon and in Idaho.

Professor William M. Jardine, president of the Kansas Agricultural College, speaking in Missouri.

Dr. C. A. Lory, president of the Colorado Agricultural College, speaking in Colorado.

Dr. S. C. Mitchell, president of Delaware College, speaking in New Jersey and Rhode Island.

Dr. E. C. Perisho, president of the South Dakota Agricultural College, speaking in South Dakota and Montana.

A. J. Glover, editor of Hoard's Dairyman, speaking in Minnesota.

Dean Alfred Vivian, of the College of Agriculture, Ohio State University, speaking in Iowa.

Dr. T. F. Hunt, dean of the College of Agriculture, University of California, will go direct from California for speeches in the state of Washington early in April.

SCIENTIFIC NOTES AND NEWS

The annual meeting of the National Academy of Sciences will be held at the Smithson-

ian Institution in Washington on April 22, 23 and 24. The program includes accounts of war activities in different branches of science and reports of the results of several important scientific researches by members of the academy and others. The Hale lectures will be given by Professor John C. Merriam, of the University of California. His subject is "The beginnings of human history from the geologic records."

PROFESSOR COMFORT A. ADAMS, of Harvard University and the Massachusetts Institute of Technology, is the nominee of the directors of the American Institute of Electrical Engineers for president for the year beginning August 1.

SURGEON-GENERAL SIR ALFRED KEOGH, G.C.B., has been appointed to the Order of the Companions of Honor for services in connection with the war.

DR. BENJAMIN F. ROYER, Harrisburg, acting commissioner of health of Pennsylvania, will deliver the memorial address on the late commissioner, Dr. Samuel G. Dixon, at the Academy of Natural Sciences, Philadelphia, on April 9.

DR. H. L. RUSSELL, dean of the college of agriculture of the University of Wisconsin, has been appointed by the Food Administration to take charge of the division of butter and cheese, in succession to Mr. George E. Haskill.

PROFESSOR CLARENCE A. WALDO, Ph.D., late of Washington University, St. Louis, Mo., retired last commencement from the Thayer professorship of mathematics and applied mechanics, as professor emeritus and is now living at 401 West 118th St., New York City.

JAMES ZETEK, professor of biology and hygiene at the Instituto Nacional de Panama, has been appointed entomologist of the Board of Health Laboratory, Ancon Hospital, Canal Zone.

DR. HARRY B. YOCOM, professor of zoology at Washburn College, has been commissioned first lieutenant in the Sanitary Corps and ordered to report for duty to Fort Sam Houston, San Antonio, Texas.

DR. JOHN W. KIMBALL, instructor in chemistry and physics at the dental school of Western Reserve University, has been called to Washington to undertake chemical work for the Army. Dr. Kimball has been granted leave of absence from the university and will leave immediately to take up his new work.

PROFESSOR ELMER P. KOHLER, of the department of chemistry of Harvard University, has gone to Washington and will give his whole time, at least until the beginning of the next academic year, to chemical research for the national government. He will be at the experiment station of the Bureau of Mines as assistant to the director in charge of research problems.

FRANCIS C. FRARY, research chemist of the Aluminum Company of America, has been commissioned as captain in the ordnance reserve corps and assigned to research work in the trench warfare section, Engineering Bureau office of the chief of ordnance, Washington, D. C.

JOHN G. FRAYNE, an instructor in physics at the University of Minnesota, has enlisted in the signal corps of the army and will be sent to France.

DR. B. FRANKLIN ROYER, who has been chief medical inspector of the Pennsylvania State Department of Health for a number of years and who has supervised the work in the Harrisburg office during the long illness of Dr. Samuel G. Dixon, has been appointed acting health chief, pending the selection of a permanent successor to the late commissioner.

DR. ROBERT A. LYSTER, lecturer in public health and forensic medicine at St. Bartholomew's Hospital, and county medical officer for Hampshire, has been elected editor of *Public Health*.

PROFESSOR FREDERIC J. CHESHIRE, director of the department of technical optics at the Imperial College of Science and Technology, has been reelected president of the Optical Society of Great Britain.

MR. CLYDE L. PATCH, of the Victoria Memorial Museum, Ottawa, lectured on "Local Snakes, Frogs and Salamanders: their relation to agriculture," on February 5, under the auspices of the Ottawa Field Naturalists Club.

He discussed twenty-five different species and described observations made in eastern Ontario. The lecture was illustrated with living specimens and lantern views.

Through the courtesy of the regents and secretary of the Smithsonian Institution, a reception was tendered there on the evening of February 28 by the Chemical Society of Washington to the five hundred chemists temporarily residing in Washington for war duty. Addresses of welcome were made by Dr. Frederick B. Power, president of the society, and by Dr. George P. Merrill, head curator of geology of the Smithsonian Institution, after which brief addresses were made by Professor Frank W. Clarke, Dr. Charles L. Parsons, Major Samuel J. M. Auld, the British chemist cooperating with this government in the Gas Defense Service, Chancellor Samuel Avery, of the University of Nebraska and Professor Wilder D. Bancroft. A large proportion of the guests were in uniform and included many of academic distinction.

G. A. Lebour, for many years professor of geology at the University of Durham, died on February 7, at the age of seventy-one years.

The death is announced of C. I. Istrati, professor of organic chemistry and dean at the University of Bucharest and president of the Roumanian Academy of Sciences.

Dr. A. W. E. Erlandsen, professor of hygiene at the University of Copenhagen, has died at the age of thirty-nine years.

Owing to greatly increased activities in the Public Health Service, there is urgent need of the services of medical officers for field duty in connection with the sanitation of numerous civil sanitary districts. The salaries of the positions in question vary from $1,800 to $2,500 per annum, depending on the qualifications and experience of the appointees. Men who have been disqualified physically for the Medical Reserve Corps are eligible for appointment, provided they are not suffering from complaints which will seriously interfere with the performance of their duties. It is especially desired to secure the services of competent sanitarians and those who have had previous experience in health work. There are also numerous vacancies for sanitary engineers, scientific assistants, sanitary inspectors and others. Applications for appointment to these vacancies should be made to the Surgeon-General, U. S. Public Health Service, Washington, D. C., and in order to avoid unnecessary correspondence should include complete data concerning age, nativity, experience and training, and other necessary information.

UNIVERSITY AND EDUCATIONAL NEWS

A gift of a large tract of land has been made to Harvard University by Mr. Andrew Carnegie, President A. Lawrence Lowell, Mr. Henry L. Higginson and ten others. The tract, which comprises 2,344,000 square feet, is adjacent to the Soldiers' Field. There are no buildings on the land, and, according to university authorities, no plans have been made for the immediate use of the property.

Gifts reported at the recent Corporation meeting of Yale University, included one of $5,000 from Mrs. James Wesley Cooper, of Hartford, for the establishment of a publication fund in memory of her husband, who graduated from the college in 1865 and who was for over thirty years a member of the corporation, and $5,000 in memory of the late William A. Read of New York by his widow, to assist the work of the Yale University Press. Two bequests were also announced: $10,000 from the late Samuel J. Elder, for the college, and $5,000 from the widow of Amory E. Rowland, for the benefit of the Sheffield Scientific School.

By the will of Mrs. Eliza C. Farnham $1,200 is left to the Howard College for two Horace Farnham Scholarships.

Assistant Professor Herbert L. Seward, '06 S., of the Sheffield Scientific School of Yale University has been granted leave of absence to become head of a new school being organized by the Navy Department to train engineers for the naval service. The leave of absence granted by the corporation begins on May 1, but Professor Seward will continue in charge of the engineering instruction of the

Yale Naval Training Unit for the rest of the year.

DR. W. F. G. SWANN has accepted a professorship in the department of physics at the University of Minnesota, the appointment to take effect on August 1, 1918.

DISCUSSION AND CORRESPONDENCE

SCOTT ON THE CANONS OF COMPARATIVE ANATOMY

IN a recent number of this journal (N. S., Vol. XLVII., No. 1204) my esteemed friend, Dr. D. H. Scott, the distinguished foreign secretary of the Royal Society has published a review of my recent volume on "The Anatomy of Woody Plants." He objects, with delightful British vigor, to the Canons of Comparative Anatomy described in the seventeenth chapter. His criticisms, in fact, of the volume mainly involve these canons, which he regards as highly controversial and based on deductive evidence. Dr. Scott naturally has his own opinions on many anatomical subjects, and these are often different from my own. The question, however, as to whether the Canons of Comparative Anatomy are deductive or inductive appears to be not a matter of opinion but a matter of fact. Inductive reasoning, which is ordinarily defined as the drawing of general conclusions from particular facts, was brought into prominence nearly three hundred years ago by Sir Francis Bacon, an eminent Englishman. I must urge that the Doctrine of Conservative Organs is based on purely inductive reasoning. In accordance with that doctrine it is stated that root, leaf and reproductive axis retain ancestral anatomical features approximately in the order named. This is an induction from the facts that the reproductive axis of the Calamites and Equiseta, the reproductive axis and root of the Araucarian and Abietineous Conifers, the reproductive axis and root of *Ginkgo*, the reproductive axis and root of the higher Gnetales, all retain notable the features of organization of older or extinct allied forms. It appears to me that Dr. Scott confuses the origin of the Canons of Comparative Anatomy with their application. The Canons are derived inductively by the comparison of older with modern forms, and are employed deductively to elucidate the relations of modern forms among themselves.

The soundness of the general principles of the seventeenth chapter of my volume on anatomy has a very sincere and flattering testimony in the attitude of a small coterie of critics of the anatomical work of "Jeffrey and his school." These critics use the canons in every case, but if I may be forgiven a pun are unable to aim straight. The most recent instance of this defect is furnished by an article on the vessels of *Gnetum* in the January number of the *Botanical Gazette*. This author calls attention to the fact that vessels of the lower *Ephedra* type having end walls with many large open bordered pits are found in the root, reproductive axis, and seedling of *Gnetum*. He argues very properly from this that the *Gnetum* type of vessel has come from that found in *Ephedra* and persists in the conservative organs of the first-named genus. This conclusion is correct as far as it goes, but when the author states that the type of vessel found in *Gnetum* is different from that found in the Angiosperms he shows a surprising ignorance, since in DeBary's classic text-book of comparative anatomy published over forty years ago a number of cases of angiosperms with the *Gnetum* type of vessel terminated at either end by a single large-bordered pore have been cited. I might go on to enumerate a number of other equally sincere and flattering testimonials to the soundness of the Canons of Comparative Anatomy, although not to the accuracy of their utilizers, from recently published works. If imitation is the sincerest flattery, I am indeed flattered. A number of lines of work being carried on in my laboratory, and among these, notably an investigation on a large amount of material of Comanchean and Laramie Cretaceous Conifers, will, I think, add much strength to these generalizations.

A frank and friendly criticism such as Dr. Scott has written always helps to clear up differences of opinion by bringing forth clearer and more forcible statements from either side.

E. C. JEFFREY

THE JERUSALEM ARTICHOKE AS A WAR PLANT

In the March number of the *Scientific Monthly,* Professor T. D. A. Cockerell publishes an interesting article entitled "The Girasole, or Jerusalem Artichoke, a Neglected Source of Food." It will be interesting to add that the French Academy of Agriculture has by no means overlooked this important plant, the French name of which is *topinambour.* For the last two or three years the Comptes Rendus des Séances de l'Académie d'Agriculture has contained frequent references to the value of this crop, most of the communications having been made by M. Schribaux. In the last number, which comes to my desk today, M. Schribaux presents an interesting communication from M. Thiry, director of the Agricultural School of Tomblaine near Nancy. He says that in a normal year only about a hundred hectares are planted in Lorraine, but he believes that the plant is capable of rendering great services. In his own family they have regularly raised and eaten the *topinambour* since at least 1860. All of the agricultural land in Lorraine is not well adapted to its cultivation, only light lands being best adapted. In general, they feed the tubers to the horses, giving a little to the pigs, but never to the cattle, for they think that this diet gives the milk a bluish tinge. He states that the crop is more productive than potatoes, and they often raise at Tomblaine thirty thousand kilograms to the hectare. He uses the variety called *patate* by Vilmorin. It has more regular tubers, and while not less productive is more delicate than the ordinary variety. He has eaten them in his house for a long time, since he tasted Jerusalem artichokes in England, and he has fed them to the children of the refugees whom he has taken in. Last year the people of Nancy wished to eat them, since potatoes were out of their reach, but at that time they were beginning to germinate and were not edible. He thinks the plant is a very remarkable one, and that in fertile earth well worked it will repay the labor of the farmer with great interest. Whether the climate is severe or dry, and even when the earth is poor and weedy, the crop will still be satisfactory, and it lacks the diseases of the potato. He believes it to be *a war plant of the first order.* He thinks that a serious effort should be made to propagate this vegetable in all France.

L. O. Howard

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POISONING TREE PARASITES WITH CYANIDE OF POTASSIUM

Some three years ago there was discussion in this journal of the method of killing insect parasites of fruit trees by placing cyanide of potassium under the bark. Success was reported from such inoculation of peach trees. Others reported that cyanide of potassium mixed with other poisons, when used in the same manner, caused the death of the tree within two or three years.

Three years ago, in the spring, I bored half inch holes in each of six apple and pear trees and filling these holes with powdered cyanide of potassium, "chemically pure," plugged them up. Four of these trees were apparently dying from scale, the other two were infested but not dying. During the summer all six became free from scale and the four dying ones began to recuperate. In the fall both the apple and the pear trees bore good fruit which was palatable and harmless. All the trees are now healthy and vigorous after three years, and there are no areas of dead bark around the inoculation holes.

This seems an indication that inoculation with cyanide of potassium, when used without admixture of other drugs, is not necessarily injurious to apple and pear trees. Its effectiveness as a parasite exterminant is rendered doubtful, however, by the fact that the scale died on all my other trees which were not inoculated. One of these trees was practically dead at that time, having lost all but two of its branches, but it is now vigorous. I lost two good trees from scale before this. Scale had been becoming more and more troublesome in northern Ohio for a number of years, but three years ago many infested trees became entirely free or almost free from the pest, and in this whole region there was marked improvement in the orchards, which

are not yet back to their former bad condition.

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SYSTEMATISTS AND GENERAL BIOLOGISTS

MAY I endorse the suggestion by Dr. L. O. Howard?[1] He says that he does not know whether determination of species is important to the experimental embryologist. When, as zoological recorder for Echinoderma, it was my duty to read a large number of papers by those workers, I formed the opinion that it certainly was important, and wrote:[2]

> It is well to urge on those gentlemen the need for an accurate determination of the material with which they work. They are too much inclined to infer the universal from the particular, and to overlook the fact that species and even local races differ from one another in their reproduction and development, just as much as in their habits and perhaps more than in their structure.

This plea was strongly supported by Viguier.[3]

Accurate discrimination of species is no less necessary for the field naturalist. J. H. Fabre, always ready to gird at the museum worker, had to confess that he had confused under the one name *Eumenes pomiformis* three species of mason-wasps, so that it was not possible for him "to ascribe to each of them its respective nest" (I quote from the selection just published under the title "The Wonders of Instinct," London, Fisher Unwin).

Most geologists have by this time learned that, for lack of the precautions advocated by Dr. Howard, many of their fossil lists are not worth the paper they are printed on. Recent advances in stratigraphical geology are almost entirely due to the keener appreciation of minute specific differences.

In a word, every kind of biologist should find in the despised taxonomist a valuable, indeed an indispensable, ally; and in our museums he should recognize a depository where the evidence for his conclusions may be preserved for future generations of workers.

LONDON F. A. BATHER

[2] *Zool. Rec.*, for 1901.

[1] SCIENCE, January 25, p. 93.

[3] 1903. *Ann. Sci. Nat. Zool.*, ser. 8, Vol. 17, p. 71.

SCIENTIFIC BOOKS

Lectures on Heredity. By H. S. JENNINGS, Ph.D., LL.D., Johns Hopkins University; OSCAR RIDDLE, Ph.D., Department of Experimental Evolution, Carnegie Institution; and W. E. CASTLE, Ph.D., Harvard University. Delivered under the auspices of the Washington Academy of Sciences, Washington, D. C. 1917. Pp. 82. Bound in buckram, 50 cents.

This is the second annual series of lectures presented before the Washington Academy of Sciences and reprinted in collected form from the *Journal* of that academy.

The study of genetics has become so highly specialized that workers in the different fields have ceased, except in rare instances, to make a serious effort to coordinate their work with that of others.

Dr. Jennings's classical work on the nature of variations in lower organisms deals with one of these highly specialized branches, and students of other branches should appreciate the service rendered by Dr. Jennings in his painstaking comparison.

"Having satisfied myself as to the nature of the variations that arise in the creatures that I have studied, I have looked about to see what other workers have found; and to determine whether any unified picture of the matter can be made."

After claiming that the idea of genotypes must be admitted as a general condition, the author concludes that this result "is not final, that it does not proceed to the end."

In a uniparental organism, from which all question of the recombination of existing diversities is eliminated, Dr. Jennings finds that "the immense majority of the hereditary variations were minute gradations. Variation is as continuous as can be detected."

The points at issue between the "genotypic mutationists" and the upholders of gradual change are clearly and concisely stated. Setting aside the question whether the evidence held to support the gradual change theory is conclusive or not, he proceeds directly into territory of the mutationists and shows that the "multiple allelomorphs" found in *Droso-*

phila supply in themselves all the evidence that even an extreme selectionist should ask. To explain why large changes are observed as well as small ones it is suggested that we may be "witnessing the disintegration of highly developed apparatus instead of its building up."

Dr. Castle's contribution also deals with the controversy over the nature of evolutionary change, whether continuous or discontinuous. He, however, is less inclined than Dr. Jennings to resolve the differences between the two schools into differences in the use of terms. After allowing for the effects of the confusion in terminology, he sees "two contrasted sets of ideas," which he arranges under the headings *Darwin* and *DeVries*.

Students of paleontology, geographical distribution and classification are shown, in general, to favor the belief in gradual evolution and the efficacy of selection. The opposite view, that of discontinuous variation and stability of new forms, is held by a majority of the students of experimental breeding. Support of the former view by one who has done such thorough work as an experimental breeder must have great weight.

From the point of view taken by Jennings, it would seem that in contrasting the mode of origin and the stability of new types Castle is himself open to the criticism of using the term "type" ambiguously. If by a new type is meant anything new, most geneticists would range themselves with DeVries, but if a new type is something more comprehensive, DeVries and his followers must stand alone.

The crux of the difference between Castle's views and those of practically all classes of mutationists would seem to be in Castle's holding that selection determines in some measure the range of variation in subsequent generations. Confining the question to inherited variations, does the selection of extreme variations form new centers of distribution? To do so, it would seem that small variations must be more numerous than large ones, an assumption which would be questioned by most mutationists, including Morgan.

Although cases were encountered in Dr. Castle's own work in which selection gave no tangible results, in many characters progress was rapid and continuous, with no indication of other than physical limits, and it is held that in the smaller mammals, which Dr. Castle has studied intensively for many years, there are few characters which can safely be referred to the agency of perfectly stable genes.

That selection does, from a practical standpoint at least, produce results is abundantly shown by Dr. Castle's work. If by the use of refined reasoning his critics are able to show that change in a single Mendelian character is not the only possible explanation of the results, these critics may then be referred to Jennings's results with *Difflugia*.

Dr. Riddle has here brought together in a concise and readable form the results of his extensive experiments on the nature of sex in pigeons and has coordinated these results with the work of other investigators.

Sexual differentiation is interpreted as the expression of quantitative differences in the rate of protoplasmic activity; the more active metabolism resulting in males, the less active in females. Many lines of evidence are presented, all of which are consistent with the view that preponderance of one or the other sex is conditioned by the rate or level of metabolism. These various lines of evidence show the following characteristics to be associated with the female sex, all of them being associated also with a low level of metabolism: Large size of yolk, low per cent. of water in the yolk, high per cent. of stored material, high total stored energy, exhausted physical condition of the mother, age of the mother.

In crosses the percentage of males increases with the width of the cross to the point of infertility. Since males are characterized by a more active metabolism, there is an agreement between these results and the commonly observed increased vigor of hybrids.

Assortive mating of gametes and differential death rates are fully considered and neither

is found to furnish a possible explanation of the controlled sex ratios.

Not only can the sex of pigeons be changed but it can also be accentuated. The females hatched from the second egg of the clutch, laid in the autumn by overworked birds, are more pronounced females than the normal females of the species. This is evidenced by the persistence of a right ovary in such birds. In normal female pigeons the right ovary has completely degenerated in the week-old squab.

The literature reviewed gives evidence of a relation between rate of metabolism and sex in a great variety of animals, varying from worms to man. With sex viewed as an expression of differentiated metabolic activity, its independent origin in diverse groups of organisms ceases to be a stumbling block, being no more remarkable than that the same color should have originated independently in different groups. The work reported is confined to the animal kingdom and it should be of interest to determine whether in diœcious plants there is a corresponding differentiation in the rate of metabolic change.

Dr. Riddle's work would seem to call for discussion by those students of genetics who place the distribution of the chromosome in a causal relation to sex, since his results directly challenge this interpretation. It is shown that in some cases at least sex is determined before the segregation of the chromosomes, a fact which would seem to make chromosome number a characteristic rather than a cause of sex.

Furthermore, the challenge extends to all Mendelians, for if "one hereditary character (sex) is modifiable, is of a fluid, quantitative, reversible nature," surely the alternative nature and stability of other characters come in question.

It is worthy of note that all three investigators, though working in widely separated fields and approaching the problem of evolution from very different angles, conclude that evolutionary change is, in effect at least, a gradual process that is not beyond the power of man to man influence.

G. N. COLLINS

SPECIAL ARTICLES

THE RÔLE OF CATALASE IN ACIDOSIS

IF an inorganic acid, such as hydrochloric. be administered to an animal, it is neutralized by the alkalies of the blood and tissues; if an organic acid be administered, it is oxidized, unless the oxidative processes of the animal are defective, as in diabetes, in which case the organic acids are neutralized, as are the inorganic. This neutralization of acids leads to a depletion of the "alkaline reserves" of the body, which produces the condition known as acidosis. By the term acidosis is meant the impoverishment of the tissues and blood in alkalies. In very severe cases of diabetes, the animal is not able to burn sugar and can burn fat and protein only as far as β-oxybutyric and diacetic acids and acetone, hence the tissues of the diabetic would become acid in reaction were it not for the fact that the acids formed in this disease are neutralized by the alkalies of the tissues. Since this neutralization leads to a depletion of the "alkaline reserves" of the body in severe cases of diabetes and since acidity of the tissues is incompatible with life, the animal dies. From the foregoing it is readily understood how the intravenous infusions of sodium bicarbonate are helpful in overcoming the coma of diabetes. Besides diabetes, it is known that acidosis occurs in "surgical shock," in anesthesia, and in starvation. It is also known that in these conditions oxidation is decreased and that the accumulation of the resulting incompletely oxidized substances, acid in nature, are responsible for the acidosis. The present investigation was carried out in an attempt to find an explanation for the decreased oxidation with resulting acidosis in the conditions mentioned.

Diabetes.—Pancreatic diabetes was produced in dogs by extirpating the pancreas. Sugar appeared in the urine a few hours after the operations. About two weeks later, when the animals were in a moribund condition, they were killed and the blood vessels were washed free of blood by the use of large quantities of 0.9 per cent. sodium chloride, as was indicated

by the fact that the wash water gave no test for catalase. The tissues were then removed and ground up separately in a hashing machine. The catalase of one gram of the different tissues was determined by adding this amount of material to 50 c.c. of hydrogen peroxide in a bottle at 22° C., and as the oxygen gas was liberated, it was conducted to an inverted, graduated vessel, previously filled with water. After the oxygen gas thus collected in ten minutes had been reduced to standard atmospheric pressure, the resulting volume was taken as a measure of the amount of catalase in the gram of material. The material was shaken in a shaking machine at a fixed rate of 180 double shakes per minute during the determinations. It was found that the catalase of all the tissues of the diabetic dogs was decreased, the greatest decrease being in the heart and liver. The catalase of the heart was decreased by about 48 per cent. while that of the liver was decreased by about 72 per cent.

"Surgical Shock."—The condition of shock" was produced in cats and dogs by handling and manipulating the intestines. It was found that as the blood pressure decreased and the condition of "shock" developed, there was an accompanying decrease in the catalase of the blood, and that when the condition of "shock" was fully developed as was indicated by a fall in blood pressure to approximately 30 mm. of mercury, the catalase had decreased about 40 per cent. from the normal. Henderson observed that oxidation was decreased in "surgical shock" with resulting acidosis. Cannon has shown that in man in conditions of traumatic shock there is a condition of acidosis which is relieved by injections of solutions of sodium bicarbonate.

Anesthesia.—The anesthetics used were ether, chloroform, chloral hydrate, nitrous oxide, and magnesium sulfate. The animals used were cats, dogs, and rabbits. The ether and chloroform were administered by bubbling air through the respective anesthetics in a bottle, which was connected by a rubber tube to a cone adjusted over the snout of the animal. Chloral hydrate anesthesia was produced by the introduction into the stomachs of rabbits of 10 c.c. of a 2 per cent. solution of chloral hydrate per kilo of body weight. A mixture of nitrous oxide and oxygen in the poportion of one to five was administered to cats in the production of nitrous oxide anesthesia, while magnesium sulfate anesthesia was produced by the subcutaneous injection of 7.5 c.c. of a 20 per cent. magnesium sulfate solution per kilo of body weight. It was found that the catalase of the blood was decreased by all of these anesthetics and that the extent of the decrease was proportional to the depth of anesthesia. Chloroform and nitrous oxide, in keeping with their rapid action as anesthetics, decreased the catalase of the blood very quickly, whereas chloral hydrate and magnesium sulfate, in keeping with their slower action, decreased the catalase much more slowly, while ether occupied an intermediate position in this respect. It is recognized that there is a decrease in oxidation with resulting acidosis in anesthesia and that this is more likely to occur with a powerful anesthetic, such as chloroform, than with ether.

Starvation.—Four rabbits were used in this experiment. Two of them were killed before the period of starvation was begun, and after washing the blood vessels free of blood, the catalase of the different tissues was determined according to the method described in this paper under "diabetes." The remaining two rabbits were starved for six days, and at the end of this time the catalase of the tissues was determined in the same manner as that of the unstarved rabbits. It was found that the catalase of the voluntary muscles was decreased during starvation by 40 per cent.; that of the fat by 70 per cent.; while it remained normally high in the heart.

The conclusion is drawn that the defective oxidation in diabetes and the decreased oxidation in anesthesia, starvation, and "surgical shock"with resulting acidosis is propably due to the decrease in catalase, an enzyme found in the tissues and possessing the property of liberating oxygen from hydrogen peroxide.

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